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Indian Standard

SCHEDULES FOR WROUGHT STEELS

PART III CARBON AND CARBON-MANGANESE FREE CUTTING STEELS

(First Revision)

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NEW DELHI 110002

Gr 5 October 1979

Indian Standard

SCHEDULES FOR WROUGHT STEELS

PART III CARBON AND CARBON-MANGANESE FREE CUTTING STEELS

(First Revision)

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(*Continued on page* 17)

Indian Standard

SCHEDULES FOR WROUGHT STEELS

PART III CARBON AND CARBON-MANGANESE FREE CUTTING STEELS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (Part III) (First Revision) was adopted by the Indian Standards Institution on 5 March 1979, after the draft finalized by the Alloy Steels and Special Steels Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 Schedules for wrought steels for general engineering purposes (IS : 1570-1961) was first published in 1961. On the basis of the experience gained in the production and use of steels, the Sectional Committee has decided to revise the standard and issue it in parts. The other parts of the standard are as follows:

Part I Steels specified by tensile and/or yield properties
Part II Carbon steels (unalloyed steels)
Part IV Alloy steels (excluding stainless and heat-resisting steels)
Part V Stainless and heat-resisting steels[*]
Part VI Tool steels

0.3 The following major modifications have been made in this revision:

a) Steel designations have been modified in accordance with IS : 1762 (Part I)-1974[†]

b) Change in carbon content of grade 13S25

c) Change in mechanical properties of grades 40S18 and 40Mn2S12.

0.4 The method for designating free cutting steels is detailed in Appendix A for information.

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[*] Already published as IS : 1570 (Part V)-1972.

[†] Code for designation of Steels: Part I Based on letter symbols.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This schedule (Part III) is applicable to standards for carbon and carbon-manganese free cutting steels supplied to a specified composition (*see* Table 1).

TABLE 1 SPECIFIED CHEMICAL COMPOSITION FOR THE STANDARD STEELS

Designation		C Percent	Si Percent	Mn Percent	S Percent	P Percent
New	Old					
(1)	(2)	(3)	(4)	(5)	(6)	(7)
10C8S10	(10S11)	0·15 *Max*	0·05-0·30	0·60-0·90	0·08-0·13	0·060 *Max*
14C14S14	(14Mn1S14)	0·10-0·18	0·05-0·30	1·20-1·50	0·10-0·18	0·060 *Max*
25C12S14	(25Mn1S14)	0·20-0·30	0·25 *Max*	1·00-1·50	0·10-0·18	0·060 *Max*
40C10S18	(40S18)	0·35-0·45	0·25 *Max*	0·80-1·20	0·14-0·22	0·060 *Max*
11C10S25	(11S25)	0·08-0·15	0·10 *Max*	0·80-1·20	0·20-0·30	0·060 *Max*
40C15S12	(40Mn2S12)	0·35-0·45	0·25 *Max*	1·30-1·70	0·08-0·15	0·060 *Max*

NOTE 1 — The steel may be supplied in killed or semi-killed type. In case of killed steel, minimum silicon level should be 0·10 percent.

NOTE 2 — When required lead and other elements are specified as added elements.

2. GENERAL

2.1 While preparing Indian Standards, or revising the existing standards, steels listed in this schedule shall be selected. The specification of mechanical properties different from those given in this schedule should not be made unless special conditions of service render this essential. In that event, full reasons for the proposed departure from the steels specified in this schedule shall be submitted to the Alloy Steels and Special Steels Sectional Committee, SMDC 19, and its approval obtained.

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*Rules for rounding off numerical values (*revised*).

2.2 In addition to defining the composition limits, the specified mechanical properties applicable to the different conditions are included. Table 2 gives values for the hot-rolled or normalized condition based on ruling sections up to 150 mm and for larger sizes some adjustment of the specified tensile range for a particular range of composition may be necessary. Mechanical properties for cold-drawn bars, and for hardened and tempered bars and forgings, together with the sizes to which these properties are applicable are given in Tables 3 and 4. Table 5 gives the properties for case-hardening steels, that is, the properties obtainable in the core of the case-hardened parts after refining and quenching.

TABLE 2 SPECIFIED TENSILE LIMITS FOR BARS, BILLETS AND FORGINGS IN THE HOT ROLLED OR NORMALIZED CONDITION

DESIGNATION		TENSILE STRENGTH	ELONGATION, PERCENT, *Min* Gauge Length
New	Old		
(1)	(2)	(3)	(4)
		MPa*	
10C8S10	(10S11)	370-490	24
14C14S14	(14Mn1S14)	440-540	22
25C12S14	(25Mn1S14)	500-600	20
40C10S18	(40S18)	550-650	17
11C10S25	(11S25)	370-490	22
40C15S12	(40Mn2S12)	600-700	15

NOTE — Minimum values for yield stress may be required in certain specifications and in such cases a minimum yield stress of 55 percent of the minimum tensile strength should be satisfactory.

*1 MPa = 1N/mm^2 = 0·102 0 kgf/mm^2.

2.3 For some purposes, a minimum yield stress is regarded as a specification requirement and minimum yield stress values are, therefore, given for some of the physical conditions for inclusion in specifications, if required.

2.4 Information on the assessment of the ruling section of bars, forgings and parts is given in Appendix B.

2.5 In addition to the tensile ranges, values for the specified minimum percentage elongation corresponding to the specified tensile ranges are included in the Schedule. Different types of test pieces are used for the tensile test. The values given in this schedule are based on a gauge length of 5·65 $\sqrt{A}$ and if test pieces of other than 5·65 $\sqrt{A}$ gauge length are used elongation conversion may be obtained from IS : 3803-1974*.

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*Elongation conversions for steel (*first revision*).

TABLE 3 SPECIFIED TENSILE LIMITS FOR COLD DRAWN BARS

(*Clause* 2.2)

Designation		Up to 20 mm		Over 20 mm up to 40 mm		Over 40 mm up to 63 mm		Over 63 mm	
New	Old	Tensile Strength, *Min*	Elongation, Percent, *Min* Gauge length $5.65\sqrt{A}$	Tensile Strength, *Min*	Elongation, Percent, *Min* Gauge length $5.65\sqrt{A}$	Tensile Strength, *Min*	Elongation, Percent, *Min* Gauge length $5.65\sqrt{A}$	Tensile Strength, *Min*	Elongation, Percent, *Min* Gauge length $5.65\sqrt{A}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		MPa*		MPa*		MPa*		MPa*	
10C8S10	(10S11)	500	10	460	10	420	13	370	17
14C14S14	(14Mn1S14)	550	10	520	11	480	12	440	15
25C12S14	(25Mn1S14)	620	8	560	10	520	11	500	13
40C10S18	(40S18)	640	8	600	10	560	11	550	11
11C10S25	(11S25)	500	8	440	11	400	13	370	13
40C15S12	(40Mn2S12)	680	7	640	8	620	10	600	11

*1 MPa = 1 N/mm² = 0.102 0 kgf/mm².

TABLE 4 SPECIFIED MECHANICAL PROPERTIES FOR BARS AND FORGINGS IN THE HARDENED AND TEMPERED CONDITION

(*Clause* 2.2)

Designation		Tensile Strength	Yield Stress, *Min* (if specified)	Elongation Percent, *Min* Gauge Length	Izad Impact Value, *Min* (if specified)	Limiting Ruling Section
New	Old					
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		MPa*	MPa*		J	mm
40C10S18	(40S18)	600-750	380	18	41	60
		700-850	480	17	35	30
40C15S12	(40Mn2S12)	600-750	420	18	48	100
		700-850	500	18	48	60
		800-950	560	16	41	30

*1 MPa = 1 N/mm^2 = 0·102 0 kgf/mm^2.

TABLE 5 SPECIFIED MECHANICAL PROPERTIES FOR CASE HARDENING STEELS IN THE REFINED AND QUENCHED CONDITION (CORE PROPERTIES)

(*Clause* 2.2)

Designation		Tensile Strength	Elongation, Percent, *Min* Gauge Length	Izad Impact Value, *Min* (if specified)	Limiting Ruling Section
New	Old				
(1)	(2)	(3)	(4)	(5)	(6)
		MPa*		J	mm
10C8S10	(10S11)	500	17	55	30
10C14S14	(14Mn1S14)	600	17	41	30

*1 MPa = 1 N/mm^2 = 0·102 0 kgf/mm^2.

2.6 The notch toughness of steels after hardening and tempering is sometimes assessed by an impact test and values for incorporation in specifications, if required, are given in the relevant tables of the schedule.

2.7 The specified mechanical properties are applicable to test samples taken from a standard location which should be included in the specification.

2.8 Any additional tests apart from those given in this schedule, should also be specified in the standard as appropriate.

APPENDIX A

(*Clause* 0.4)

NEW SYSTEM OF DESIGNATION OF STEELS

A-1. GENERAL

A-1.1 The new system of designation of steel is based on the draft ISO proposal submitted by India to ISO/TC 17 ' Steel ' for formulation of an international standard. Details of the new designation system are given in IS : 1762 (Part I)-1974*.

A-2. STEELS DESIGNATED ON THE BASIS OF CHEMICAL COMPOSITION

A-2.1 Unalloyed Free-Cutting-Steels — The designation shall consist of:

a) Figure indicating 100 times the average percentage of carbon;

b) Letter ' C ';

c) Figure indicating 10 times the average percentage of manganese;

d) Symbol ' S ', ' S_0 ', ' T_e ' or 'Pb' depending on the element present which makes the steel free-cutting followed by the figure indicating 100 times the percentage content of the element. In the case of the phosphorized steels the symbol ' P ' shall be included; and

e) If necessary, symbols indicating special characteristics as follows:

1. *Method of designation* — Depending on whether the steel is killed, semi-killed or rimming variety, the following symbols shall be used to indicate the steel making practice:

   i) R = rimming steel, and

   ii) K = killed steel.

   NOTE — If no symbol is used, it shall mean that the steel is of semi-killed type.

2. *Steel quality* — The following symbols shall be used to indicate steel quality:

   Q1 = Non-ageing quality,
   Q2 = Freedom from flakes,
   Q3 = Grain size controlled,
   Q4 = Inclusion controlled, and
   Q5 = Internal homogeneity guaranteed.

---

*Code for designation of steel: Part I Based on letter symbols (*first revision*).

3. *Degree of purity* — The sulphur and phosphorus levels (ladle analysis) shall be expressed as follows:

Symbol	*Maximum Content in Percent*	
	Phosphorus	Sulphur
P25	0·025	0·025
P35	0·035	0·035
P50	0·050	0·050
P70	0·070	0·070
No symbol will mean	0·055	0·055

The above symbols use the letter ' P ' followed by 100 times the maximum percentage of sulphur and phosphorus. In case the maximum contents of sulphur and phosphorus are not same, the following procedure shall be followed:

Symbol SP shall be used to indicate the levels followed by:

a) 100 times the maximum sulphur rounded off* to the nearest integer.

b) 100 times the maximum phosphorus rounded off* to the nearest integer.

Example:

Maximum sulphur = 0·045 percent
Maximum phosphorus = 0·035 percent

Designation: SP 44.

4. *Weldability guarantee* — Guaranteed weldability of steel as determined by tests mutually agreed between the purchaser and the manufacturer shall be indicated by the following symbols:

W = Fusion weldable, and
W_1 = Weldable by resistance welding but not fusion weldable.

5. *Resistance to brittle fracture* — Symbols ' B ', ' B0 ', ' B2 ' or ' B4 ' indicating resistance to brittle fracture based on the results of the V-notch Charpy impact test.

For steels B, B0, B2 and B4 a test should be made with Charpy V-notch specimens, taken in the direction of rolling with the notch perpendicular to the surface of the plate or product.

---

*Rounding off shall be done according to the rules given in IS : 2-1960 Rules for rounding off numerical values (*revised*).

Steels B, B0, B2 and B4 are characterized by an average V-notch Charpy impact value according to the following table:

Steels	*Specified UTS Range*			
	370 to 520 MPa*		500 to 700 MPa*	
	Energy	Temperature	Energy	Temperature
(1)	(2)	(3)	(4)	(5)
	J	°C	J	°C
B	28	27	40	27
B0	28	0	28 40	—10 0
B2	28	–20	28 40	—30 —20
B4	28	–40	28 40	–50 –40

6. *Surface Condition* — The following symbols shall be used to indicate surface condition:

S1 = Deseemed or scarfed;
S2 = Descaled;
S3 = Pickled (including washing and neutralizing);
S4 = Shot, grit or sand blasted;
S5 = Peeled (skinned);
S6 = Bright drawn or cold rolled; and
S7 = Ground.

NOTE — If no symbol is used, it shall mean that the surface is in as-rolled or as-forged condition.

7. *Formability (applicable to sheet only)* — The following symbols shall be used to indicate drawability:

D1 = Drawing quality,
D2 = Deep drawing quality, and
D3 = Extra deep drawing quality.

NOTE — If no symbol is used, it shall mean that the steel is of ordinary quality.

---

*1 MPa = 1 N/mm^2 = 0·102 0 kgf/mm^2.

8. *Surface finish (applicable to sheet only)* — The following symbols shall be used to indicate the surface finish:

F1 = General purpose finish,
F2 = Full finish,
F3 = Exposed,
F4 = Unexposed,
F5 = Matt finish,
F6 = Bright finish,
F7 = Plating finish,
F8 = Unpolished finish,
F9 = Polished finish,
F10 = Polished and coloured blue,
F11 = Polished and coloured yellow,
F12 = Mirror finish,
F13 = Vitreous enamel finish, and
F14 = Direct annealed finish.

9. *Treatment* — The following symbols shall be used to indicate the treatment given to the steel:

T1 = Shot-peened,
T2 = Hard-drawn,
T3 = Normalized*,
T4 = Controlled rolled,
T5 = Annealed,
T6 = Patented,
T7 = Solution-treated,
T8 = Solution-treated and aged,
T9 = Controlled cooled,
T10 = Bright annealed,
T11 = Spherodized,
T12 = Stress-relieved,
T13 = Case-hardened*, and
T14 = Hardened and tempered.

Note — If no symbol is used, it means that the steel is hot-rolled.

---

*Including tempering if done.

10. *Elevated temperature properties* — For guarantee with regard to elevated temperature properties, the letter ' H ' shall be used. However, in the designation only the room temperature properties shall be shown. Elevated temperature properties shall be intimated to the purchaser separately by the manufacturer.

11. *Cryogenic quality* — For guarantee with regard to low temperature properties, the letter ' L ' shall be used. However, only the room temperature properties shall be indicated in the designation.

Examples:

35C10S14K	Free-cutting steel with average 0·35 percent carbon, 1 percent manganese and 0·14 percent sulphur, killed quality.
20C12Pb15T14	Free-cutting steel with average 0·15 percent lead, 0·20 percent carbon and 1·2 percent manganese, hardened and tempered.

A-2.2 Free Cutting Alloy Steels — The steel designation shall be as for low, medium and high alloy steels as given in IS : 1762 (Part I)-1974* except that depending on the percentage of S, Se, Te, and Zr present, the designation shall also consist of the chemical symbol of the element present followed by the figure indicating 100 times its content.

Examples:

X15Cr25Ni15S40	Alloy free-cutting steel with carbon 0·15 percent, chromium 25 percent, nickel 15 percent and sulphur 0·40 percent.
X12Cr18Ni3S25	Alloy free-cutting steel with 18 percent chromium nickel 3 percent and sulphur 0·25 percent.

---

*Code for designation of steel: Part I Based on letter symbols (*first revision*).

APPENDIX B

(*Clause* 2.4)

INFORMATION ON RULING SECTION

B-1. The mechanical properties obtained from a steel of a given composition are fundamentally influenced by the speed of cooling from a temperature above the upper critical point, that is, from the hardening or normalizing temperature. Also for a given method of cooling, for example, oil-quenching, the rate of cooling is strongly affected by the size and shape of the part being treated. Therefore, for a steel of a given composition, the mechanical properties attained are affected not only by the method of cooling employed, but also by the size and shape of part at the time of heat treatment. Thus, although it may be possible to obtain effective hardening by oil-quenching a small section of a steel of a particular composition, it may not be possible to produce satisfactory hardening throughout the mass when parts of larger cross-sectional dimensions are oil-quenched. In such circumstances a steel of a different composition has to be selected. This inter-relation between the mechanical properties obtained and the size and shape of the part at the time of heat treatment is sometimes referred to as ' mass effect ':

B-2. It is, therefore, necessary, when selecting the steel which should be used to attain certain specified mechanical properties after heat treatment, to know the size and shape of the part to be heat-treated. The cross-sectional dimensions of that portion of the forging or part, where it is most important to obtain the desired mechanical properties, are regarded as the ' ruling sections ' of the part. In the case of round bar, the diameters is the ruling section, but, as many shapes other than round bars require heat treatment, it is desirable to be able to relate the rates of cooling of other shapes to their equivalent sections of round bar. The diameters of round bars, the centres of which would cool through a given temperature range at the same rate as the centres of rectangular and square bars of selected sizes have been assessed and the resulting ' equivalent ruling sections ' are given in Tables 6 and 7. Table 6 gives the equivalent ruling section in terms of diameter of round bar for rectangular and square sections when oil-quenched, while Table 7 gives the same information for air-cooling. As examples of how the tables may be applied, the centre of a square section of 100 mm sides will, when oil-quenched, cool at the same rate as a round section of 108 mm diameter and the equivalent ruling section of a slab 140 mm wide × 60 mm thick will, for oil-quenching, be 88 mm. In the case of other regular sections, close approximations may usually be made since the order of decreasing rate of cooling is, round, octagonal, hexagonal and square, while oval sections with major axis *a* and minor axis *b* will cool more slowly than a round bar of diameter *b* but faster than *a* rectangle *a* × *b*.

TABLE 6 CONVERSION OF RECTANGULAR AND SQUARE SECTIONS INTO EQUIVALENT RULING SECTIONS, OIL QUENCHING

(*Clauses* 2.4, B-2)

WIDTH OF SECTION IN	THICKNESS OF SECTION									
	10 mm	20 mm	30 mm	40 mm	50 mm	60 mm	80 mm	100 mm	120 mm	140 mm
	DIAMETER OF EQUIVALENT ROUNDS									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	10	—	—	—	—	—	—	—	—	—
20	14	21	—	—	—	—	—	—	—	—
30	16	26	32	—	—	—	—	—	—	—
40	17	29	37	43	—	—	—	—	—	—
50	17	31	40	48	54	—	—	—	—	—
60	17	32	43	51	59	65	—	—	—	—
80	17	32	46	57	66	74	87	—	—	—
100	17	33	47	60	71	80	96	108	—	—
120	17	33	48	62	74	85	102	117	130	—
140	17	33	48	63	76	88	108	125	140	152
160	17	33	48	63	77	90	112	131	148	×
180	17	33	48	63	77	91	115	136	154	×
200	17	33	48	63	78	92	117	140	×	×
225	17	33	48	63	78	92	119	143	×	×
250	17	33	48	63	78	92	120	145	×	×
300	17	33	48	63	78	92	121	148	×	×
350 and over	18	33	49	63	78	92	121	150	×	×

× Greater than 160 mm.

TABLE 7 CONVERSION OF RECTANGULAR AND SQUARE SECTIONS INTO EQUIVALENT RULING SECTIONS, AIR COOLING

(*Clauses* 2.4, B-2)

Width of Section	Thickness of Section									
	10 mm	20 mm	30 mm	40 mm	50 mm	60 mm	80 mm	100 mm	120 mm	140 mm
	Diameter of Equivalent Rounds									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	10	—	—	—	—	—	—	—	—	—
20	13	20	—	—	—	—	—	—	—	—
30	15	24	30	—	—	—	—	—	—	—
40	16	27	34	40	—	—	—	—	—	—
50	16	29	38	45	51	—	—	—	—	—
60	17	30	41	49	55	61	—	—	—	—
80	17	32	45	54	62	70	81	—	—	—
100	17	33	47	58	68	76	90	102	—	—
120	17	34	49	62	72	82	98	111	122	—
140	17	34	50	64	76	86	104	119	132	142
160	17	34	51	66	79	90	109	126	140	152
180	18	35	51	67	81	93	114	132	148	×
200	18	35	52	68	83	95	117	137	154	×
225	18	35	52	69	85	98	121	142	×	×
250	18	36	53	70	86	100	125	147	×	×
300	18	37	54	71	88	104	131	155	×	×
350 and over	20	39	59	78	97	115	152	×	×	×

× Greater than 160 mm.

B-3. In the case of parts of nonuniform section, not only is it necessary to consider which is the most important portion of the forging in which the specified properties are essential, but also to consider the relation of the length of any enlarged portion to its diameter. For example, in the case of a forging with a barrel, the length L of which is greater than the diameter D (*see* Fig. 1A), this diameter will be the ruling dimension. In the case of a collar, the diameter D_1 of which is greater than the thickness T (*see* Fig. 1B), the collar may be considered as a disc of which the thickness is the governing dimension although the ruling section of the part as a whole for practical purposes will be the diameter D_2. For forgings where the dimension *B* and thickness *T* of the portion of largest cross section are similar (*see* Fig. 1C), the dimension *A*, between the centre and the nearest points of the external surface will in general determine the ruling section.

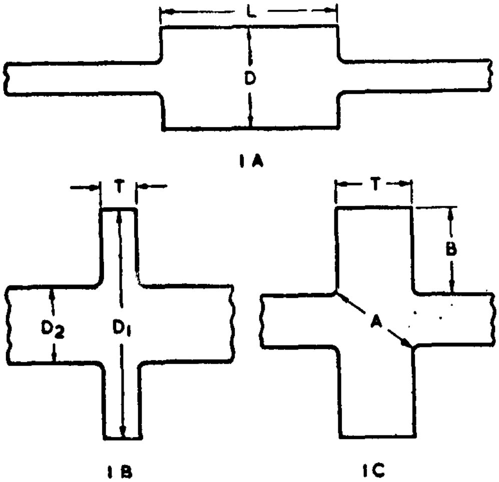

FIG. 1 TYPICAL DIAGRAM FOR THE ASSESSMENT OF RULING SECTION

B-4. In Table 4, which gives the mechanical properties for steels in the hardened and tempered condition, are included the limiting ruling sections, that is, the maximum diameter of round bar to which the specified properties apply after hardening and tempering. For example, in the case of steel 40C10S18 (40S18) the properties associated with a tensile strength of 700-800 MPa* be obtained in round bar up to 100 mm in diameter or in other shapes whose equivalent ruling sections do not exceed that dimension, but for a tensile strength of 800-950 MPa*, the limiting ruling section is 63 mm. Therefore, to obtain a tensile strength 800-900 MPa* in parts with ruling sections greater than 63 mm other steels, such as 35Mn2Mo28 or 40Cr1Mo28 would be necessary. The application of the different steels given in Table 6 or different tensile ranges in relation to the limiting ruling section is summarized in Table 7.

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*1 MPa = 1 N/mm^2 = 0·102 0 kgf/mm^2.

(*Continued from page* 2)

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